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REPORT ON WATER QUALITY AND FLOW REGULATION SOUTHERN NEVADA WATER SUPPLY PROJECT FOR THE BUREAU OF RECLAMATION, DEPARTMENT OF INTERIOR REGION 3, BOULDER CITY, NEVADA

Public Health Service
Denver, Colorado

April 1963

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FOR
THE BUREAU OF RECLAMATION, DEPARTMENT OF INTERIOR
REGION 3, BOULDER CITY, NEVADA

Study Area

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VIII
Division of Water Supply and Pollution Control
Denver, Colorado

NATIONAL TECHNICAL INFORMATION SERVICE

April 1963

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FOR
THE BUREAU OF RECLAMATION, DEPARTMENT OF INTERIOR
REGION 3, BOULDER CITY, NEVADA

U. S. DEPARTMENT OF HEALTH EDUCATION, AND WELFARE
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Colorado River Basin Water Quality Control Project
April 1963

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REPORT ON WATER QUALITY AND FLOW REGULATION IN THE SOUTHERN NEVADA WATER SUPPLY PROJECT

Agreement for performance of this study was made in correspondence dated November 5 to 29, 1962, between the Director, Region 3, Bureau of Reclamation, Boulder City, Nevada, and the Director of the Colorado River Basin Water Quality Control Project, Public Health Service, Denver, Colorado.

Purposes of this report are to appraise the quality for municipal and industrial use of a proposed supplemental water supply from Lake Mead to the Las Vegas-Boulder City area and to examine the need, if any, of storage and release of Colorado River water to compensate for degradation of river quality caused by the proposed diversion and return flow.

The report has been reviewed with the Director of Public Health Engineering, Nevada State Department of Health, to whom we are indebted for useful comment and suggestions.

BRIEF DESCRIPTION OF PROJECT AND PROJECT AREA

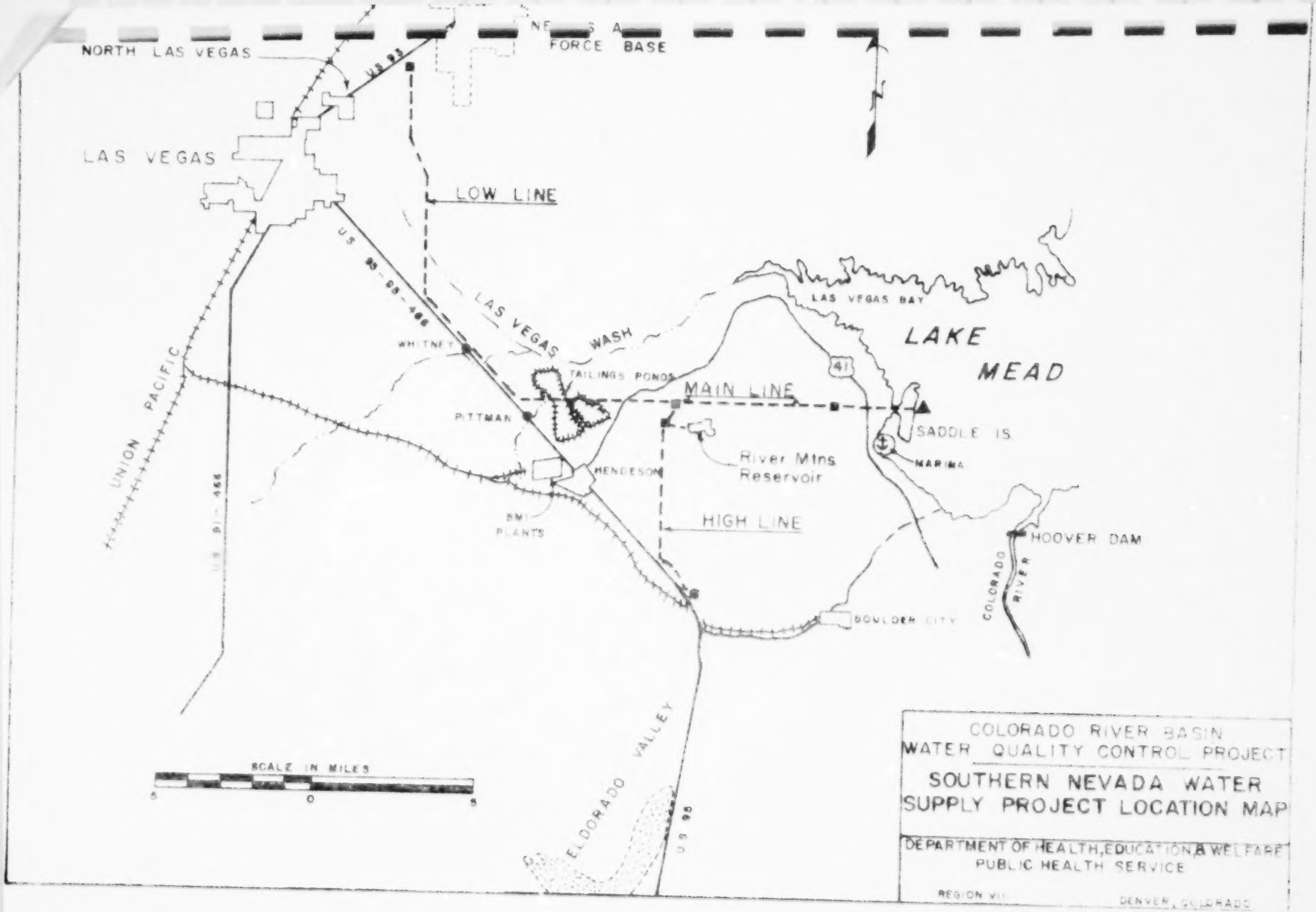
The area of study is the central part of Clark County in Southern Nevada, comprising the cities of Las Vegas, North Las Vegas, Henderson, Boulder City and their adjacent urbanized areas, as well as Nellis Air Force Base 8 miles northeast of Las Vegas (Figure 1). Tourism, national defense activities, and mining and chemical industries have been leading factors in the swift economic development of the Las Vegas metropolitan area in recent years, of which an idea is conveyed by the population census figures for Las Vegas and Clark County over the past four decades.

TABLE I

POPULATIONS

Year	Las Vegas	Clark County
1920	2,304	4,859
1930	5,165	8,532
1940	8,422	16,414
1950	24,624	48,289
1960	64,605	127,016

The regional climate is arid. Precipitation at Las Vegas averages less than 5 inches annually. Two major sources of water sustain the area--ground water, and surface water from the Colorado River impounded in Lake Mead by Hoover Dam. The easterly communities, Boulder City, Henderson, and its adjacent complex of chemical and metallurgical industries use Lake Mead water only. Until 1955 Las Vegas and adjacent areas depended entirely on ground water, extracted from storage in the



COLORADO RIVER BASIN
WATER QUALITY CONTROL PROJECT

SOUTHERN NEVADA WATER SUPPLY PROJECT LOCATION MAP

DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE

REGION VIII — DENVER, COLORADO

FIGURE 1

1a

saturated alluvium of Las Vegas Valley. Heightened demand led to an overdevelopment of the ground water supply. Annual withdrawal attained a volume of about 53,000 acre-feet, compared with an average annual recharge of only 25,000 acre-feet (5). This imbalance, accompanied by declining water levels, led to restriction of the use of ground water in the highly developed portions of Las Vegas Valley. The drilling of additional wells for irrigation has been virtually prohibited by the State Engineer of Nevada. Wells may continue to be constructed for domestic supply, but rate of withdrawal and conditions of use are strictly regulated.

In 1955 the Las Vegas Valley Water District began the purchase of Lake Mead water to supplement ground water sources. (This organization furnishes water to the City of Las Vegas and adjacent area.) The additional supply is obtained from Basic Management, Inc. (BMI), which serves as the water supply and distributing agency for the City of Henderson and its neighboring industrial plants. In 1960 about 11 percent of the total supply of the District, or 2,440 acre-feet, came from Lake Mead.

The City of North Las Vegas, which had been wholly dependent on its wells, has turned to the Las Vegas Valley Water District for additional water, purchasing in 1960 816 acre-feet, about 18 percent of its total consumption. Nellis Air Force Base has a water quality problem. Its most productive wells are also the most strongly mineralized, and if pumped to capacity, tend to draw increasing amounts of high-sulfate waters from nearby gypsiferous formations. The water supply contract of the City of Henderson with BMI calls for reduced delivery commencing in 1967. The contract will expire in 1980. Consequently, this community is looking for an alternative supply. Finally, provision is desired for water service to prospective industrial developments in the Eldorado Valley southwest of Boulder City.

In response to the need for comprehensive water supply planning, and with the encouragement of the State and local agencies concerned, Region 3, U. S. Bureau of Reclamation have prepared a scheme for supplementary water supply from Lake Mead for the entire area, based on the following projections of water requirements to the year 2020, shown in Table II.

The principal engineering components of the Project as it is now envisaged are the following:

1. A main-line aqueduct system, comprising an intake and pumping station on the east side of Saddle Island in Lake Mead, and an aqueduct, partly in tunnel, about 7-1/2 miles long ending in a terminal reservoir and pumping station 4 miles northeast of Henderson. The initial pump installations will have a capacity of 155 cubic feet per second (cfs), reckoned sufficient to meet demand until 1987. It is capable of eventual expansion to 510 cfs. Maximum pumping lift to the aqueduct terminal reservoir is about 700 feet. The submergence of the intake will vary from about 120 to 180 feet, depending on the operating level of Lake Mead.

TABLE II

ESTIMATE OF GROSS WATER REQUIREMENTS
BY
U. S. BUREAU OF RECLAMATION

Community	Millions of Gallons Yearly			
	1960	1980	2000	2020
Las Vegas Valley Water District	16,000	36,000	47,000	53,000
City of North Las Vegas	1,700	4,400	8,800	17,000
City of Henderson	1,360	2,700	5,200	15,400
Henderson Basic Industries	4,000	8,000	14,000	21,000
Nellis Air Force Base	700	920	1,200	1,600
Boulder City	740	1,900	2,900	4,300
Eldorado Valley	-	140	1,200	7,000
Total Project	24,500	54,060	80,300	119,300

The project has not reached the stage of detailed design. When it does so, an intake structure permitting draft at various levels should be considered in order to permit drawing water of the best quality available. Substantial variations have been found in late summer in temperature and dissolved solids content of the upper 150 feet of Lake Mead waters (3).

2. A low-line delivery system, comprising gravity-flow laterals extending in a general westerly and north-westerly direction from the aqueduct terminal to serve Las Vegas, North Las Vegas, and Nellis Air Force Base.

3. A high-line delivery system running south and southeast from the aqueduct terminal. It will make water service available to the higher portions of the City of Henderson, the BMI system, and Boulder City, with provision for future supply to the Eldorado Valley industrial area. High level storage will be afforded at the River Mountains Reservoir, holding a maximum of 3,500 acre-feet, to meet peak water demands above capacity of the aqueduct terminal pumping station.

The United States Fish and Wildlife Service have proposed development of River Mountains Reservoir for recreational fishing. They have suggested stocking its waters with rainbow trout and utilizing it as a public fishing area. The

Fish and Wildlife Service believe that substantial economic benefits, amounting to $40,000 annually, can be realized by using River Mountains Reservoir for recreational fishing.

One possible disadvantage is foreseen. If profuse algae growths should occur in the reservoir they may cause objectionable taste and odor. Destruction of algae in River Mountains Reservoir by use of copper sulfate may harm or kill the fish unless its application is very skillfully controlled. Rainbow trout have been reported vulnerable to copper sulfate in amounts as low as 0.5 parts per million (ppm). This concentration must often be exceeded for effective algae control, especially in alkaline waters (7). Treatment for taste and odor control in the reservoir therefore may prove difficult or impracticable, and the municipal water systems supplied from this source should be prepared to cope with the problem at their treatment works.

The Nevada State Health Department will require strict sanitary safeguards in the use of River Mountains Reservoir for fishing. The Public Health Service concurs in this necessity of reducing public health hazards in a source of municipal water supply.

QUALITY OF LAKE MEAD WATER SUPPLY

Physical and chemical properties of Colorado River water near Boulder City are compared with existing municipal well water supplies, and with Nellis Air Force Base wells in Table III. In comparison with the municipal supplies, the river water is about 50 percent harder and 150-200 percent more saline (Figure 1)[1/] Chloride and sulfate concentrations are much higher. Sulfate content approaches the maximum for domestic water supplies, 250 ppm, recommended in the 1962 Drinking Water Standards of the Public Health Service. Iron and fluorides fall within recommended limits. The river water at Boulder City is acceptable as to mineral quality, in fact slightly better than Lake Havasu, 150 miles downstream, which serves the Metropolitan Water District of Southern California.

Water in this hardness range (320-348 ppm) can be considered very hard. Softening to about 125 ppm would be desirable for municipal and domestic use, as practiced formerly by Boulder City, and presently at the LaVerne Plant of the Metropolitan Water District. For some types of local industrial use a greater degree of softening will no doubt be required, including water for boiler feed, laundering, and ice-making

It has been learned from a creditable though unofficial source that soils in the area of River Mountains Reservoir contain manganese. Inundation of such soils might leach significant amounts of manganese, resulting in

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[1/] Salinity as used in this context refers to total dissolved mineral solids concentration.

TABLE III
PHYSICAL AND CHEMICAL QUALITY
OF SURFACE AND GROUNDWATER SUPPLIES IN PROJECT AREA

(All values except pH in milligrams per liter)

Source	Date	Temp. °C	pH	Dl	Alk.	SO_4	Fe	F	Total Hdn.	TDS
Colorado River near Boulder City[1/]	Water Year 1961	12.5-17.0	7.8-8.3	70-88	108-134	210-243	0.00-0.01	0.2-0.3	320-348	675-711
Las Vegas[2/]	11/2/51	-	7.6	3.9	236	46	0.10	0.3	229	266
North Las Vegas[2/]	3/29/51	21.1	7.6	3.2	226	33	0.02	0.1	206	235
Nellis Air Force Base, composite of ten wells[3/]	undated	-	8.1	18	227	92	-	0.7	221	476

[1/] Department of Health, Education, and Welfare, National Water Quality Network, unpublished data for 1961 water year; except Fe and F data from USGS W.S.P. 1523, pp. 181-182.

[2/] U. S. Geological Survey, Water Supply Paper 1300. Reservoir complsites of groundwater supplies.

[3/] U. S. Bureau of Reclamation, Region 3, unpublished data.

undesirable concentrations in the reservoir water. The 1962 Drinking Water Standards of the Public Health Service recommend a limit of 0.05 ppm in domestic water supplies. Manganese is removed from water in the lime-soda water softening process as well as by conventional water purification methods. Its removal is not difficult technically, provided that proper facilities are available.

Bacteriological quality of Colorado River water at Boulder City has been generally good as shown by the following tabulated densities of coliform organisms during the water years 1960, 1961, and 1962, observed in the sampling program of the National Water Quality Network of the Public Health Service.

TABLE IV

MOST PROBABLE NUMBERS (MPN)
OF COLIFORM ORGANISMS
PER 100 ML.

COLORADO RIVER NEAR BOULDER CITY

Water Year	Number of Samples	Median Value, MPN	Highest Value, MPN
1960	50	1.	130
1961	48	1.5	33
1962(part)	35	3.	8000

The extreme value of the 3-year series, 8,000 per 100 milliliters on June 5, 1962 is unique and has not been approached in later tests.

Concentrations of organic chemicals separated by the carbon filter technique have been small. Carbon chloroform extractables (CCE) averaged 43 parts per billion (ppb) during the water year 1961, and 44 ppb up to February in the water year 1962, with minimum and maximum values of 30 and 58 ppb respectively. Water soluble and oxygenated compounds comprised the greater part of the CCE group. The former are often considered to represent partly-oxidized hydrocarbons, and the latter, aged and stabilized organic pollutants including aldehydes, ketones, and esters. Motor fuel and the exhaust gases of pleasure craft operating in Lake Mead are a known source of hydrocarbons, and a further putative source of organic chemical pollutants is in the wastes from chemical plants near Henderson. These wastes may enter Lake Mead via Las Vegas Wash.

The 1962 edition of the Drinking Water Standards recommends a maximum of 200 ppb for CCE's in domestic water supplies. All samples taken at Boulder City in the period 1959-1962 were well under that limit.

No excessive radioactivity has been found in any Colorado River sample at Boulder City since inception of the National Water Quality Network monitoring program in 1959.

To sum up, Lake Mead is an excellent source of municipal water supply although as mentioned before softening is desirable owing to its excessive hardness. Facilities should be available to users to cope with taste and odor in the raw water, in the event that algae blooms occur in River Mountains Reservoir. The Nevada State Health Department and the Public Health Service agree that complete water treatment should be considered for all municipal users in planning of the over-all project. Increasingly heavy recreational use of Lake Mead in the area of the proposed raw water intake justifies planning for full treatment rather than chlorination alone.

Complete water treatment (i.e. coagulation, sedimentation, filtration, chlorination, and other processes needed) probably could best be provided at a point in the main line system which would assure that completely treated water would be available anywhere along the low line and high line delivery systems. The aqueduct terminal might provide such a location. In this manner present and future residential, commercial, and industrial developments could be served with safe and palatable water from any convenient takeoff points on the low line and high line systems. The purification plant should be planned to treat all raw waters, both water pumped direct from Lake Mead, and that bypassed to River Mountains Reservoir.

RETURN FLOWS AND THEIR EFFECTS

Information furnished by the Bureau of Reclamation in Table II and in Table V below, in conjunction with data from other souces, permits calculation of the future change in mineral quality in the Colorado River resulting from operation of the Southern Nevada Project. Table V gives significant hydrologic factors and calculated increases in salinity. Results are conditioned by water quality upstream. It is postulated here that the present weighted mean value of dissolved mineral solids in upstream water entering Lake Mead, 688 ppm[1/], will be maintained without material change. Mean salinity of ground waters in the Las Vegas Basin is assumed to remain fixed at 330 ppm. On these premises the rise in salinity in releases from Lake Mead, resulting from operation of the project, would have been about 1 part per million in 1960, and will be about 12 parts per million in 2020.

These increases in salinity, even in the ultimate state of the project, are less than 2 percent, and do not appear to require compensatory measures for maintenance of water quality.

[1/] Value from Bureau of Reclamation, Region 3, Boulder City, Nevada.

In the event that quality of water deteriorates upstream in the Colorado River, the absolute rise in salinity of Lake Mead outflow would be greater than the values shown below. The increase of dissolved salts in the outflow, due to Project operation, would be very nearly proportional to the rise in concentration upstream; for example, a 70 percent rise in salinity of water entering Lake Mead would result in a rise of about 21 ppm, instead of 11.8 ppm shown below. The ratio of increase in salinity, caused by the Southern Nevada Project diversion, would continue to be less than 2 percent.

TABLE V
SUMMARY OF PROJECT OPERATIONAL STUDIES
(Values in Acre-Feet per Year unless Noted Otherwise)

Item	1960 Values	2020 Values
Gross Water Requirements of the Southern Nevada Project	75,000	366,000
Groundwater Supply (1)	46,000	25,000
Gross demand on Lake Mead	29,000	341,000
Return Flow to Lake Mead	20,000	118,000
Net Export from Lake Mead	9,000	223,000
Mean Annual Flow of Colorado River entering Lake Mead	11,840,000	9,188,000
Mean Annual Flow of Colorado R. entering Lake Mead, less Project export	11,831,000	8,965,000
Net Export of Mineral Salts from Lake Mead, Tons/Year	-9,000	63,000
Rise in Salinity in Outflow from Lake Mead, ppm	1.1	11.8

(1) 1960 draft at present estimated amount. Draft for 2020 at annual recharge rate estimated by U. S. Geological Survey.

The only path of return flow from Las Vegas Valley to Lake Mead is Las Vegas Wash. Total annual runoff in that stream averaged nearly 15,000 acre-feet in 1957-1960. Flow was made up of about two-thirds sewage and industrial waste water and one-third of rising ground water (spring discharges and seepage). Storm runoff was small, about 500 acre-feet yearly. Much of the treated sewage of Las Vegas is reused for irrigation; the amount has not been measured, but was estimated to be about one-third of the 1960 total discharge, or 3,700 acre-feet. The Southern Nevada Power Company's thermoelectric plant at Whitney also uses large amounts of reclaimed sewage for cooling, 2.5 to 3.0 million gallons per day, purchased from Clark County Sanitation District.

The Bureau of Reclamation in an inquiry at Las Vegas found that the mineral pickup in the cycle of municipal use of water was 75 tons per

year per thousand population. At the prevailing rate of sewage flow, 101 gallons per capita daily, that was equivalent to 490 ppm. Since the original water supply has about 300 ppm of dissolved salts, the sewage effluent is evidently reclaimable by the criterion of salinity. Prospects are that increasing amounts of municipal sewage in Las Vegas Valley will be salvaged for irrigation and rough industrial uses.

The position is different in respect to the industrial waste waters. Effluents from the Henderson industries and Southern Nevada Power Company are heavily mineralized. Waste discharge from the power plant enters Las Vegas Wash direct. Effluent of the Henderson industries flows in a drainage ditch to a broad area of tailings ponds north of Henderson. There it is dissipated by evaporation and by percolation into the shallow, free gound water zone. There is a strong suggestion that part at least of the percolated effluent reappears as rising ground water along Las Vegas Wash, and eventually enters Lake Mead. This question deserves further inquiry.

Table VI summarizes main facts on quality and volume of flow in the streams mentioned above.

Table V showed that under future conditions there will be a net export of salts from Lake Mead into the project area, estimated to reach 63,000 tons per year in 2020. The question of harmless disposal has been considered by the Bureau of Reclamation project planning staff. It is expected that the wastewaters of Boulder City and the Eldorado Valley industrial plants with their salinity load will be discharged into Eldorado Valley, there to be dispersed by evapotranspiration and seepage. The Valley is a geologic bolson, or totally enclosed basin with no external drainage, and has no usable underlying ground water. At need the wastewaters of Henderson and its industries could also be pumped into Eldorado Valley for disposal.

REDUCTION OF STREAMFLOW

Mean annual flow in the Colorado River entering Lake Mead, under cultural and economic development of 2020, is estimated by the Bureau of Reclamation at 9,188,000 acre-feet. If the net export from Lake Mead is 223,000 acre-feet, the reduction in outflow due to operation of the project is therefore about 2.4 percent.

Flow in the lower Colorado is already regulated by Hoover Dam within relatively narrow limits, and this control should be strengthened by operation of Glen Canyon and other upstream reservoirs. Maximum monthly discharge is but rarely more than twice the minimum in any year. A flow reduction in the order of 2 percent, due to the Southern Nevada Project diversion, therefore will not decrease significantly the downstream capacity of the river to assimilate organic wastes, as might be the case in an unregulated stream. No need is foreseen to augment low flows under ordinary operating conditions.

TABLE VI
QUALITY AND FLOWS[1/]
LAS VEGAS WASH AND TRIBUTARY WASTEWATERS

Stream	Type of Water	Estimated Annual Discharge, Acre-feet	Quality in ppm									
			pH	Ca+Mg	Na+K	HCO_3	Cl	SO_4	Fe	F	Hdns	TDS
Las Vegas Sewage Plant	Municipal Sewage	11,000	7.6	97	827(?)	398	106	230	0.3	3.3	312	634
So. Nevada Power Co.	Cooling & blowdown	1,100	7.4	250	206	102	473	1100	0.9	2.3	756	2414
Henderson Industries	Chemical & metallurgical waste waters	8,500	2.0	153	3060	-	4023	1338	-	1.2	440	7858
Las Vegas Wash	Natural stream below waste-water discharges	15,000	8.0	1008	1160	373	1973	2375	-	1.4	3080	7242

[1/] Water analysis from samples taken May 4, 1962, by U. S. Bureau of Reclamation. Estimates of flow from Leeds, Hill & Jewett report, Reference (6).

SUMMARY - CONCLUSIONS AND RECOMMENDATIONS

1. Lake Mead water, although harder and more saline than the better groundwaters of Las Vegas Valley, is acceptable as to mineral quality. No excessive radioactivity nor organic chemical concentrations have been found. Softening is desirable for domestic supply, and probably necessary for such local industrial uses as boiler feed water, laundering and ice manufacture.

2. Bacteriological quality of the Lake Mead source has been very good hitherto. Nevertheless the intense and growing recreational uses of Lake Mead, in vicinity of the proposed raw water intake, make it necessary to consider complete treatment in all municipal use of water from this source. Facilities for complete treatment will also make it possible to control special water quality problems which may occur, viz. taste and odor due to algal growths in reservoirs, and manganese in water stored in the River Mountains Reservoir.

3. A water treatment plant should be located and planned so as to serve the entire delivery system, both high-line and low-line.

4. Use of River Mountains Reservoir for recreational fishing is permissible under sanitary safeguards to be stipulated in detail by the Nevada State Department of Health, provided that completely treated water is furnished to all persons and communities served from that reservoir.

5. Export of Colorado River water to Las Vegas and Eldorado Valleys is expected to cause a rise in concentration of mineral salts in releases from Lake Mead, varying from about 1 part per million initially, to 12 parts per million in 2020, provided that present upstream quality can be maintained. If upstream water quality should deteriorate, salinity in the outflow of Lake Mead, due to operation of the Southern Nevada Project, would rise proportionately. As the maximum anticipated rise in salinity is less than 2 percent, special measures for quality control do not appear necessary.

6. Net export of Lake Mead water to Southern Nevada Project may reach 223,000 acre-feed annually in 2020, or 2.4 percent of the predicted average yearly inflow. Since discharges from Lake Mead are regulated within rather narrow limits, the anticipated loss of flow downstream will not affect materially the river's capacity to assimilate organic wastes, and no need is foreseen to augment low flows for abatement of pollution. Construction of the Southern Nevada Project would not appear to create a need for additional storage for water quality control, as provided for in the Federal Water Pollution Control Act.

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